AN OPTIMIZATION OF THE PLASTIC INJECTION MOLDING PARAMETERS FOR SPORT EQUIPMENT BY USING DOE METHODS

RADHWAN BIN HUSSIN

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Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

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ABSTRACT

This thesis, research about the defect on plastic product in injection molding process. During producing a product using injection molding process, various of defects such as warpage, weld lines, shrinkage and sink mark can be occurred. A set of Optimal setting of injection molding parameters is very important to be determined after various trials has been made, because to reduce and controlling the quality on defect of the injection molded product. The purpose of this research is to minimizing warpage and shrinkage defect on material Polycarbonate(PC) thermoplastic and simulate the injection molding process using Moldflow Plastic Insight software (MPI).Optical glasses has been selected as a product to be studied and design the model by using Unigraphic NX 7.5. The approach based on Design of Experiment (Taguchi Method) has been implemented to analyze and optimize the processing parameters such as mold temperature, melt temperature, packing time, packing pressure, cooling time, cooling temperature, and runner size. Experimental plans available in the form of Orthogonal Arrays. Minitab Software using for automatic experiments design and analysis of results based on Design of Experiments (Taguchi Method) to find the best setting of injection molding plastic part.

ESPECIALLY DEDICATED TO

My beloved wife

Noorzalifah Bt Mohamed

My supportive parents

Hussin Bin Talib

Rosnah Bt Saad

My wonderful brothers and sisters

Noraini Binti Hussin

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ABSTRAK

Tesis ini, menjalankan penyelidikan berkenaan kecacatan yang terhasil pada produk plastik didalam proses pengacuan suntikan. Semasa menghasilkan produk menggunakan proses pengacuan suntikan, pelbagai kecacatan seperti melenting, garis kimpal, pengecutan dan tanda tenggelam boleh berlaku. Satu set parameter optimum pengacuan suntikan adalah sangat penting untuk ditentukan selepas pelbagai ujian telah dibuat bagi mengurangkan dan mengawal kualiti kecacatan produk acuan suntikan. Tujuan kajian ini adalah meminimumkan kecacatan melenting dan pengecutan pada bahan polikarbonat (PC) termoplastik dan proses simulasi pengacuan suntikan dengan menggunakan *Moldflow Plastics Insight Software (MPI)*. Cermin mata optik telah dipilih sebagai produk yang akan dikaji dan model direkabentuk dengan menggunakan aplikasi UNIGRAPHIC NX 7.5. Pendekatan berdasarkan *Design of Experiment (Taguchi Method)* telah dilaksanakan untuk menganalisis dan mengoptimumkan parameter seperti suhu acuan, suhu leburan, masa padatan, tekanan padatan, masa penyejukan, suhu penyejukan, dan saiz pelari. Pelan eksperimen didapati dalam bentuk *Orthogonal Arrays*. Perisian *Minitab* digunakan untuk merekabentuk eksperimen secara automatic dan menganalisis keputusan dengan berdasarkan *Design of Experiment (Taguchi Method)* bagi mencari satu set parameter terbaik terhadap plastik acuan suntikan.

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CHAPTER 1

INTRODUCTION

In recent years, Plastic injection molding is one of the most important polymer processing operations in the plastic industry and it is the fastest growing major industries now days. Every year, plastic products increases rapidly for replace product plastic with other material products to saving the manufacturing cost , as well as make sure it works the same or better than the existing . It is a good situation can be seen in the increase of percentage of plastics used in industry today's. Mostly, people are depending on plastic products to make a human life easier and simple. Therefore plastic products play an important role in human life and are widely used. Injection molding product has been used in the daily application such as for household appliances, industry field and sport equipments because plastic materials has low cost and light in weight compare to other material.

With this process, it has opened the door to applications never thought possible before. These are emerging both as product innovations and as existing products converted from materials such as metal, glass, wood or paper to plastics for competitive and economic advantages.

1.1 Introduction to the Problem

Nowadays, the design of plastics injection molding product becomes more complicated and the requirement for quality characteristic is keep increase. Plastic injection molding process produces various defects such as warpage, sink marks, weld lines and shrinkage. Warpage and shrinkage is a common issue related with injection molding process and shall be minimized. The defects of injection molding process usually arise from several sources, which include the preprocessing treatment of the plastic resin before the injection molding process, the selection of the injection-molding machine, and the setting of the injection molding process parameters.

The easiest way to do the set-up on the injection-molding machine is based on the machine set-up operator or technician's experience, or trial and error method. This trial and error method is unacceptable because it is time consuming and not cost effective. Some industries still using this method and produces so many products abandoned in order to determine the most appropriate parameter. This method cannot find the most appropriate parameters to reduce the defect of the product, so that should provide some jigs to clamp the product after the injection molding process for reducing the defect like warpage. Accordingly, it has increased the production cycle.

Therefore, using design of experiment for this study is to find the optimal parameters to minimize defects produced after injection molding process that can be increase productivity with save costs in manufacturing industries.

1.2 Objective of Project

The objective of the study is:

i. To study the modeling/analysis of plastic injection molding parameters with moldflow plastics insight software.

ii. To optimize the process parameters using Design of Experiment (Taguchi Method).

1.3 Scope of the Project

The scope of the study for this project consists:

i. Defect warpage and shrinkage will be observed for the optimized parameters.

ii. Parameters to be studied include mold temperature, melt temperature, packing time, packing pressure, cooling time, cooling temperature, and runner size.

iii. Moldflow plastics insight software and Design of experiment will be employed.

1.4 Methodology of Study

This research is divided into two parts. Part one is done in first semester and part two is done in the second semester. The activities of part one consists of literature review on plastic injection molding process and parameters, analyzing the product including the consideration on mold temperature, melt temperature, packing time, packing pressure, cooling time, cooling temperature, and runner size by using MoldFlow software and collect the data. The product will be designed by using Unigraphics NX7.5 software.

Then it is further continued part two with the study on optimization by using Design of Experiment (Taguchi Method) of plastic defect on the machine parameter which affects on the product. From Design of Experiment (Taguchi Method), it will get the best parameters of the product.

1.5 Significance of Finding

The research will be fine the defect of parameters in injection molding process for the Selected product. Hopefully at the end of this project, the research will be:

i. Able to understand the parameters for injection molding process.

ii. Able to use Mold Flow software to analyze the defect in injection molding process.

iii. Able to do the optimization by using Design of Experiment (Taguchi Method) for the part selected and any parts in the future.

1.6 The Purpose and the Limit of This Study

The main objective of this thesis is to study the modeling/optimization of plastic injection molding parameters with combination of CAD and CAE on sport equipment. DOE method was used to optimize the process parameters incorporated with three levels in every parameter. Those parameters are mold temperature, melt temperature, packing time, packing pressure, cooling time, cooling temperature, and runner size. By doing this, hope to get a better product quality with fewer defects and moreover, will affecting the cost of scrap productions. Furthermore, Moldflow Plastic Insight software was used to simulate injection-molding process and show the prediction of how large defects that were happen during process. There is warpage and shrinkage defect that will become issue to be optimized.

1.7 Report Structure

This thesis is arranged by dividing into six chapters. It includes introduction, literature review, methodology, results and discussion, conclusion and recommendation. The contents of each chapter are briefly explained as follows:

Chapter 1: **Introduction** – overviews of hard coating research and several studies related to this research were done. The scope of study and objectives of the work are identified.

Chapter 2: **Literature review** –Literature review on injection molding process, injection molding parameters, material to be used, Unigraphics software, MoldFlow Software and Design Of Experiment (Taguchi Method).

Chapter 3: **Research methodology** – The methodology of the project, include the flow chart for the whole thing on how the study is done. Also, contains brief explanations of the method to be used.

Chapter 4: **Results and Discussion** – Includes the experiment results from MoldFlow Plastics Insight software analysis and result from Design of Experiment (Taguchi Method). Discussion, Results represented by graph and graphic image to provide understanding and easier analysis.

Chapter 5: **Conclusion** -The value of the project itself and the recommendation for the same kind of project to be developed in the future are determined in this chapter. Finally, the conclusion about the whole field of study in the experiments, based from the objectives of the study.

1.8 Summary

In this chapter, the overview of the study such as, introduction to the research area, objective of the study, scope of the study and methodology of the study and also significance of findings is presented. The next chapter will discuss the literature reviews on plastic injection process and parameters.

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